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Environmental Effects of Dredging

Technical Notes



WETLANDS CREATED FOR DREDGED MATERIAL STABILIZATION AND WILDLIFE HABITAT IN MODERATE TO HIGH WAVE-ENERGY ENVIRONMENTS

PURPOSE: This note describes successful techniques for developing marsh on dredged material in moderate to high wave-energy environments defined below for habitat creation and substrate stabilization. Marsh creation is often much more economical and practical for dredged material stabilization than the more conventional riprap or revetment methods. Additionally, marsh development on dredged material often offers the advantage of creating wildlife and fisheries habitat, making dredged material disposal more acceptable to environmental regulatory agencies and concerned citizens.

BACKGROUND: Marsh development has been used by Corps of Engineers (CE) districts to stabilize dredged material and establish wetlands in various environments since the early 1970s (Landin 1984). Early marsh development techniques focused on areas with low wave-energy environments and consequently higher probabilities of successful marsh establishment. These areas were usually exposed to average fetches of less than 9.0 km and were in coves (Knutson and Woodhouse 1983) or on shores sheltered or away from prevailing winds (Webb, Allen, and Shirley 1982). In these areas, conventional planting techniques are adequate for creating marsh. These techniques usually consist of transplanting single sprigs (rooted stems) either by using spades or mechanized planters. In conventional planting, no attempt is made to protect the plant from waves or to stabilize the plant stem. Recent efforts have focused on practical techniques for developing marsh on dredged material exposed to moderate to high wave energies previously considered too harsh for marsh planting. Examples of such efforts include using expedient breakwaters and new techniques of stabilizing plant stems. Moderate to high wave-energy environments are defined here to have average fetches over 9.0 km and are areas typified by headlands and straight beaches. This definition is consistent with that of high energy (greater than 8.0 km average fetch) planting sites given by Hardaway, Thomas, and Zacherle (1982) and with that of Knutson and Steele (1987), who examined success rates of 67 dredged material sites in the Chesapeake Bay area. They concluded that average fetch appears to be the most useful indicator of potential planting success on dredged material areas in Chesapeake Bay.

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Breakwaters

One method of establishing marsh in a moderate to high wave-energy environment is to couple breakwaters and transplanted sprigs landward of the breakwater. Experience suggests that a breakwater is only necessary for the first 2-3 years after planting, until the marsh sprigs spread by rhizomes and completely cover the target planting area (Newling and Landin 1985). Therefore, only less expensive and expedient breakwaters, such as sandbag, floating tire, and tire-pole breakwaters, are considered in this note.

Breakwaters should be placed far enough offshore to allow maximum marsh development in breadth (seaward to landward). They should be placed in water depths less than 2.0 m mean low water (mlw), but more than 0.75 m mlw. Marsh planting should begin at a distance equal to or exceeding half an average wavelength landward of the breakwater. This will prevent scouring and erosion of the marsh from turbulence and backwash caused by the breakwater.

Sandbag breakwater. A sandbag breakwater was successfully used in 1975 to protect a developing salt marsh on a dredged material site on Bolivar Peninsula in Galveston Bay, TX (Figure 1) (Allen et al. 1978). There, a breakwater with a 305-m-long and 1.5-m-high front was constructed using 0.5- by 1.4- by 2.9-m nylon-coated bags. Sprigs of smooth cordgrass (*Spartina alterniflora*) and saltmeadow cordgrass (*Spartina patens*) were planted landward of the sandbag breakwater. The developed marsh is the only marsh on the bay side of

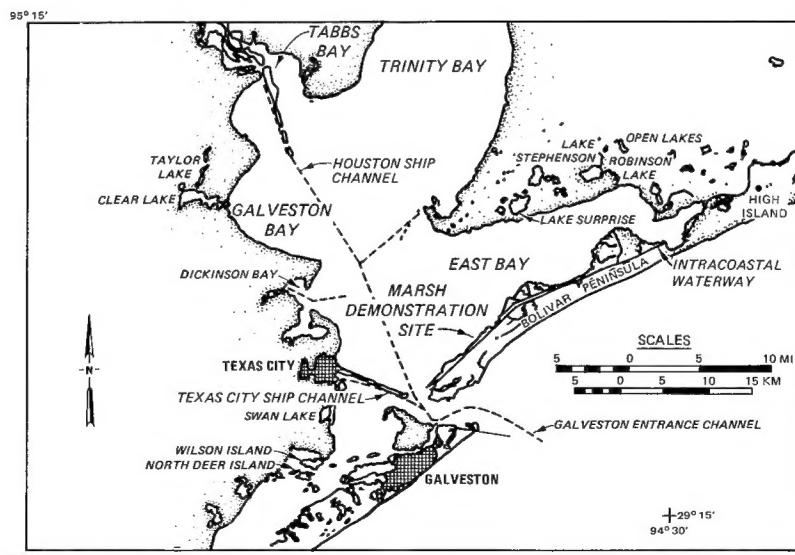


Figure 1. Marsh demonstration site on Bolivar Peninsula, Galveston Bay, TX

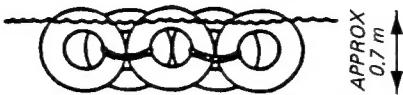
Bolivar Peninsula, partly because of a long (32-km) northwest wind fetch that produces large waves in the winter. The sandbag breakwater provided enough initial protection for the transplants to become established, and the marsh is still functioning well (Newling and Landin 1985, and Landin 1986).

Floating tire breakwaters. Floating tire breakwaters (FTBs) with shoreward salt marsh plantings have been used successfully to stabilize shores of unconfined dredged material deposits at two sites on the Gulf Coast. In 1981, a two-tier FTB (Figure 2) and smooth cordgrass sprigs stabilized part of a dredged material dike in Mobile Bay (Allen and Webb 1983). The dike formed one side of a three-sided, 485-ha confined disposal facility (CDF) called Wilson Gaillard Island (formerly called Theodore Disposal Island), in the middle of Mobile Bay (Figure 3). The stabilized area is subject to an 11.2-km fetch from the north (Figure 3). The FTB was erected after a previous conventional marsh planting had failed.

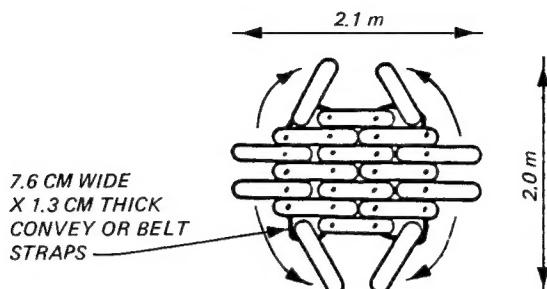
A three-tiered FTB was tested in 1984 on Bolivar Peninsula, TX, 1 km west of the 1975 site described earlier (Figure 1). The configuration was selected for field testing after wave-tank studies demonstrated that it could reduce wave energies by as much as 80 percent (Markle and Cialone 1987). Smooth cordgrass was planted shoreward of the breakwater using both conventional single-stem and specially stabilized transplants (discussed later). Plantings unprotected by a breakwater were also established nearby as a control. Initial results indicate that the protected areas have an average of 43 percent coverage by smooth cordgrass, while none of the unprotected, single-stem conventional plantings have survived. Forty-three percent coverage after 1-2 years is similar to that seen at the original Bolivar Peninsula (sandbag breakwater) site. Expansion of the marsh and continued success at the newer site is expected and will be monitored for several years.

Tire-pole breakwater. A breakwater consisting of tires threaded on 15.2-cm-diam poles (Figure 4) was also tested at the Bolivar Peninsula site in 1984. Shoreward plantings similar to those used behind the three-tiered breakwater were employed. Twenty-seven months later, marsh extended across most of the protected area with an average 47 percent plant cover in the stand. Only a relatively unprotected area at an open end of the breakwater has failed to vegetate. As with the three-tiered FTB area, the area protected by the tire-pole breakwater is also expected to thrive and expand.

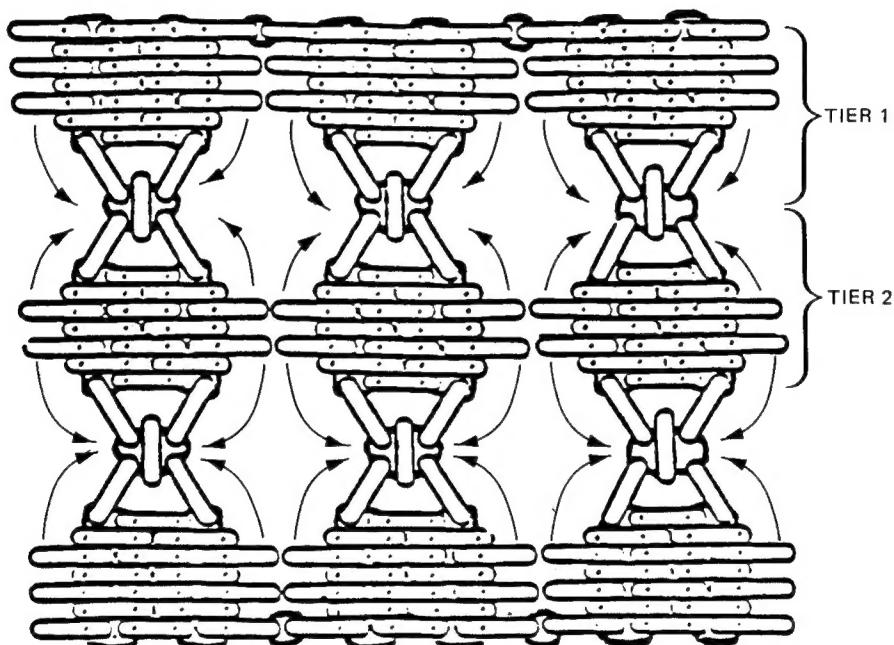
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PROFILE SCHEMATIC OF ONE FTB MODULE



PLAN SCHEMATIC OF ONE FTB MODULE



PLAN SCHEMATIC OF SEVERAL FTB MODULES

NOTE: ARROWS DENOTE THAT OUTER TIRES OF 18-TIRE MODULE ARE TURNED IN DIRECTION OF ARROW TO SERVE AS CONNECTORS TO OTHER MODULES.

Figure 2. Profile and plan schematics of a two-tier FTB, illustrating its construction by strapping tires and tire modules together

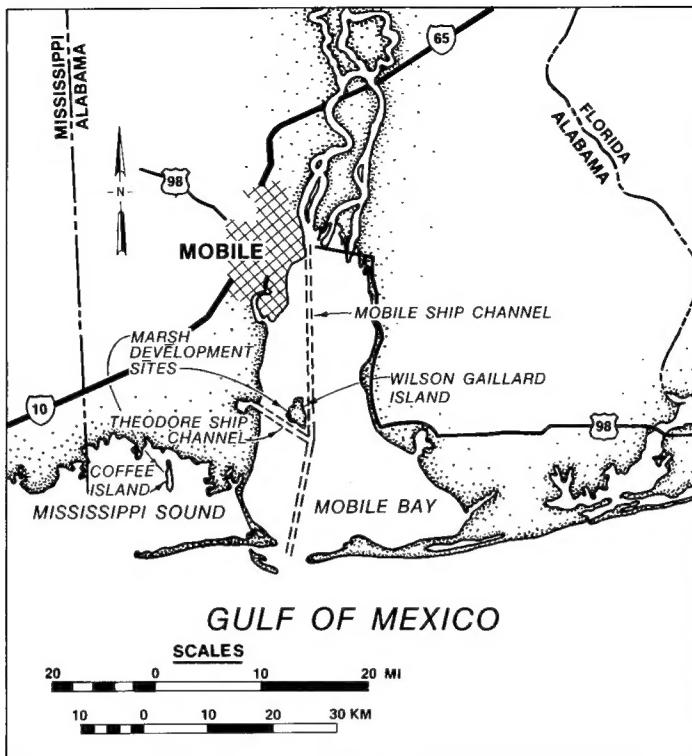


Figure 3. Gaillard Island, Mobile Bay, AL, and Coffee Island, Mississippi Sound, AL, marsh development sites

Planting Techniques for Plant-Stem Stabilization

Breakwaters are a good means of promoting marsh establishment, but other more visually attractive and possibly less expensive techniques exist that may be just as effective. In 1983, the US Army Engineer Waterways Experiment Station (WES) began to work with planting techniques that focus on plant-stem stabilization. The concept is to strengthen the attachment of the plant to the substrate to reduce the likelihood of its being washed out by wave attack and thereby avoid the necessity of a breakwater.

Twelve plant-stem stabilization and conventional planting techniques were tested in Mobile Bay in 1983. The techniques were exposed to about 0.6-m maximum wave heights of various fetches and directions, the maximum being an 11.2-km fetch from the north (Allen, Webb, and Shirley 1984). The conventional single-stem planting techniques proved unsuccessful. Three techniques using erosion-control mats, plant rolls, and burlap bundles demonstrated

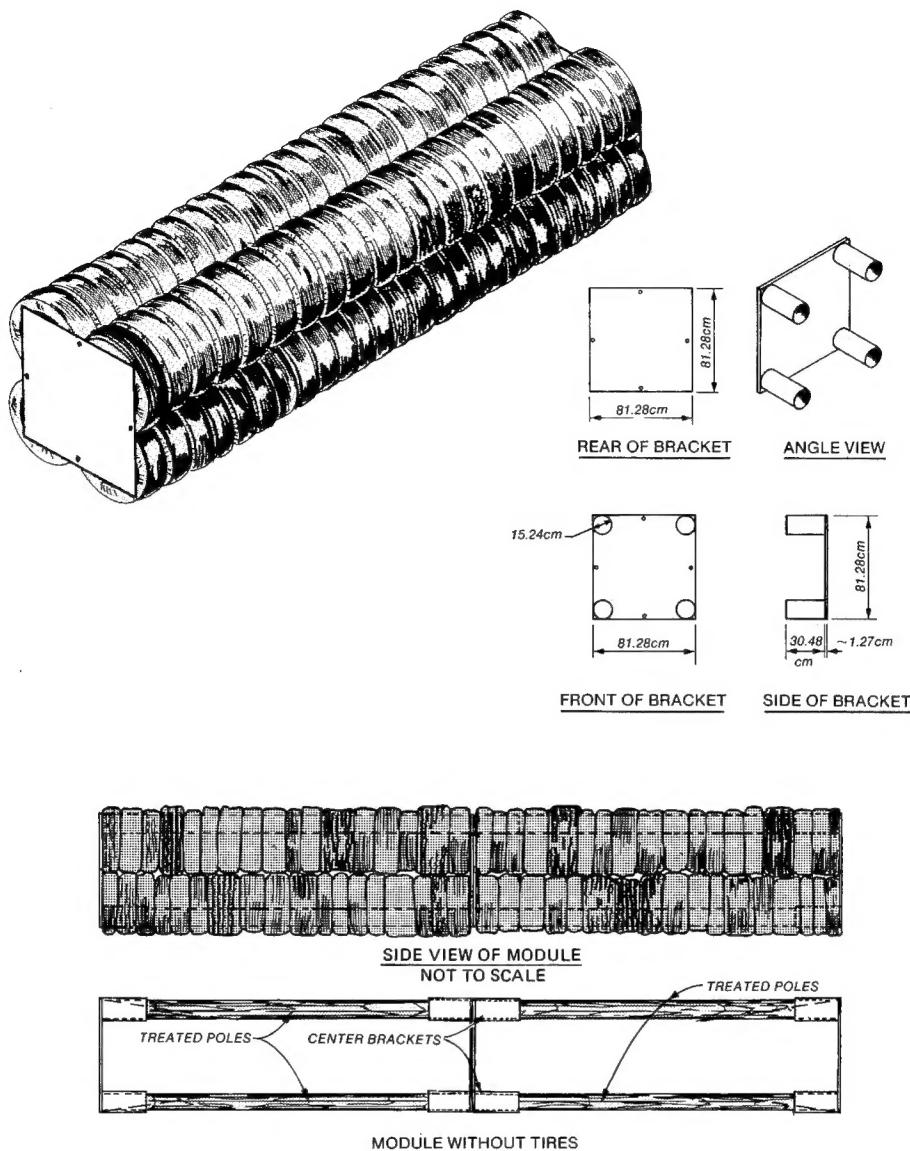


Figure 4. Schematic of fixed tire-pole breakwater

enough potential at Gaillard Island (Allen, Webb, and Shirley 1984) that they were subsequently tested in demonstration plots on Bolivar Peninsula. They were also tested at Southwest Pass on the lower Mississippi River. Potential usefulness of the plant rolls was also demonstrated along a 0.5-km front at Coffee Island in the Mississippi Sound (Figure 3). Results of these demonstrations are described in Allen, Shirley, and Webb (1986), and successful techniques to date are summarized below.

Erosion control mat. A Paratex* biodegradable fabric mat consisting of 0.1 kg/m² natural fibers was laid like carpet on the shore at the previously described Bolivar Peninsula site. Then, single stems of smooth cordgrass were planted on 0.5-m centers through slits cut in the material (Figure 5). The edges of the mat were nailed between 5- by 15-cm boards that were then buried in the sediment (Allen, Webb, and Shirley 1984). Four 6- by 9-m plots of the planted mat were placed adjacent to, parallel with, and outside the immediate influence and protection of breakwaters. Twenty-seven months later, three of four original plots remained with an average 41 percent plant cover. Success within the three remaining plots was similar for both those plots protected by breakwaters and those unprotected.



Figure 5. Smooth cordgrass sprigs inserted into fabric mat at Bolivar Peninsula

Plant roll. A plant roll is constructed by placing soil and six transplant clumps (several stems from one intact root mass) at 0.5-m intervals on a strip of 3.7-m-long by 0.9-m-wide burlap. The sides and ends of the burlap are brought together around the plants and fastened with metal rings. This creates a 3-m-long roll of plants and soil (Figure 6). The plant rolls are placed parallel to the shoreline and buried to such a depth that only the plant stems are exposed.

* The contents of this note are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such products.



Figure 6. Plant rolls constructed on site ready for installation

A mixture of single-stem transplants and plant rolls was used successfully at a demonstration site at Coffee Island (Figure 3) in the Mississippi Sound (AL). The site consisted of clayey dredged material and had a maximum fetch of 16 km. Stabilization with smooth cordgrass was undertaken to control erosion. Plant rolls (one row) were placed end to end seaward of single-stem transplants (Figure 7a) over a linear distance of about 0.5 km to cover an area 5 to 10 m wide.

Periodic inspection of this demonstration planting revealed that new stems emerging from the plant rolls satisfactorily colonized and stabilized the eroding dredged material face after 1-1/2 years (Figure 7b). Recent inspection (after 1-1/2 years of growth) of the site demonstrated that the marsh fringe showed signs of accreting sediment, a feature which will further protect the island from erosion.

Plant rolls have not always proved successful; they were washed away at the Bolivar Peninsula site. Two explanations for this are possible. At the Bolivar Peninsula site, the rolls were tested on sandy material with small test plots, and plant rolls appear to be more prone to wash out when they are used on sandy material than on clayey material, because clay is a more stable substrate. Also, small plots are more likely to fail than continuous planting because small separated plots encourage gullying between them which eventually erodes the plots.



a. Smooth cordgrass 2-1/2 months after planting using plant rolls seaward with single-stem transplants planted landward



b. Smooth cordgrass 1-1/2 years after planting using plant rolls and single-stem transplants

Figure 7. Coffee Island, Mississippi Sound, AL, marsh demonstration site

Costs

Costs of moderate- to high-energy environment planting techniques are given in Table 1 and range from \$48.00 to \$242.00 per lin m for a marsh 20 m broad (seaward to landward). Traditional erosion-control construction techniques, such as rock revetments and sheet-pile bulkheads, are much more expensive than these vegetative alternatives, often as much as 5 to 10 times more, depending upon the desired width of protection and logistical factors.

Table 1. Costs of Planting Technique*

| <u>Planting Technique</u> | <u>Cost per Plant</u> | <u>Cost/Linear Meter (20 m deep)</u> |
|---|-----------------------|--------------------------------------|
| Single-stem plants (conventional planting) | \$0.15 | \$ 12.00 |
| Plant roll | 0.60 | 48.00 |
| Paratex mat | 1.58 | 126.00 |
| FTB with planted sprigs | 1.58 | 126.00 |
| Tire/pole breakwater with planted sprigs | 1.95 | 154.00 |
| Sandbag breakwater** with planted sprigs | 3.06 | 242.00 |

* Costs are based on an hourly labor rate of \$6.00 plus 10¢/plant for digging, gathering, and transporting. Costs of materials are included; other direct and indirect costs are not included. Costs per linear meter also assume that plants are placed on 0.5-m centers and are planted in a swath 20 m wide.

** Costs of a 1.5-m-high sandbag breakwater are based on information provided by Mr. James L. Wells, Chief, Dredging Section, US Army Engineer District, Wilmington, 12 April 1988.

Conclusions

The stabilization techniques described here are still experimental and must be used with care. When used properly, they offer considerable promise for cost savings over conventional erosion-control techniques. The habitat developed is an additional benefit that may be applied to the mitigation process or used to improve the attractiveness of a site to local interests.

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